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**CONSTRUCTION AND USE OF A GEOGRAPHICAL INFORMATION SYSTEM
OF SOME MEDITERRANEAN BENTHICS COMMUNITIES.
ITS APPLICATION TO THE AREA OF TOULON (SOUTHEAST OF FRANCE)**

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ABSTRACT

This paper presents an overview of the structure of a regional Geographical Information System for mediterranean benthics communities. The area of the GIS is located between the cities of La Ciotat and Giens in the southeast of France.

The particularity of this GIS versus the others usually described in the literature is that all layers describe the same theme but seen at different moments, with different techniques used by different oceanographers. A method was developed to synthetize on a pixel basis the content of all these layers according to weights depending mainly upon the date and the techniques of measurements. This method gives also the map of "disagreement" which displays at each pixel the difference between the synthetic map and the most frequent class taking the weights into account (modal class).

This GIS is implemented on a micro-computer IBM-PC like.

1 . INTRODUCTION

For many years, the mediterranean benthic communities have been mapped by a number of oceanographers. Different sampling techniques and tools were and are used for this mapping, namely airborne surveys, direct submarine observations and bionomic analyses of samples obtained by dredging, and they depend upon the scientific objectives and the scale of the studies (Cuvelier, 1976 ; Cuvelier-Kareth, 1979 ; Meinez *et al.*, 1981 ; Augier, 1982).

Most maps use the geographical grid of Service Hydrographique et Océanographique de la Marine (S.H.O.M.) of the French Navy which is in Mercator projection, or of the Lambert III projection of Institut Géographique National. Others maps are directly drawn starting from airborne surveys without geometric rectification, hence displaying scale distortions within the map. Within the same area, many maps can exist. Usually, they are all different by the reasons above described. They are also disseminated into written reports of more or less difficult access and their use by the scientific communities is not easy.

A few maps have been already gathered into a synthetic map by Bellan *et al.* (1980) but without much criticism about the construction and results. Another empirical synthesis has been made by Jeudy de Grissac *et al.* (1986) but it takes into account only one theme : the *Posidonia oceanica* (Linnaeus) Delile. Nowadays the development of micro-computer as well as the low price of information storage onto optical digital disk make the synthesis of this set of maps possible at low cost. The aim of this paper is to present the implementation of such a regional GIS, the synthesis method and its results applied to a set of maps.

Though looking to the same area, the map produced by an author depends strongly upon the observation technique used. Also the mapping process requires interpolation methods which make use of a priori knowledge which in turn depends upon the author of the map. At last same objects depicted in two different maps are often labelled differently because of a lack of standardized codes.

Therefore we face an unusual problem for GIS. Rather than dealing with different thematic layers as a GIS usually does, each layer of our GIS is a representation of the same themes but seen differently within each layer. In that sense, we may consider the mapping of the benthic communities as a stochastic process masking a natural evolution (or none) of the benthic communities and each layer is a representation of this process. The aim of the synthesis method is to establish the synthesis of the contents of the layers according to constraints depending mainly upon the date of the measurements and upon the measurement techniques used to draw up each map.

Of course this GIS offers features in image management, processing and display and makes mostly use of the image processing software CARTO-PC^(R). The GIS is implemented on a micro-computer IBM-PC like. Data are stored onto an optical digital disk of WORM type (Write Once, Read Many). Various standard graphic boards are supported ranging from low resolution (200 x 200, 16 colours) to high resolution (1024 x 1024, more than one million colours).

2 . IMPLEMENTATION AND STRUCTURE

2.1 . Area of GIS

The area under study is located in the southeast of France, between the cities of La Ciotat and Giens (fig. 1). The geometric grid use for this GIS is the Lambert III projection. The spatial coordinates of this area are :

- 43°0'37" N to 43°12'11" N
- 5°32'48" E to 6°6'16" E

or in Lambert III projection :

- 3086 N to 3105 N
- 861 E to 910 E

In this area, a lot of maps exist and they have been listed by Jeudy de Grissac *et al.* (1986). The maps drawn with a scale up to 1/18,000 have not been used as well as the redundant maps. The scales of the selected maps range between 1/14,000 and 1/122,000. In accordance with the demand of oceanographers, the scale chosen for this GIS is 1/25,000, and the reference map is provided by the map of Institut Géographique National (IGN) at that scale.

2.2 . Data set

Eighteen maps have been selected. Each map is made with more or less taxons or classes, and the classes are often different between one map and the others because the maps have different objectives (geological maps, benthic communities maps, etc...). Nevertheless, it is necessary to aggregate some of the classes of different maps into the same class because their name changes but their content is the same. After the aggregation of attribute data, a number of twelve classes have been selected for the creation of the GIS, but this number can be extended to 256 classes. This is the first difference between our GIS and the GISs usually described in literature (Arnberg *et al.*, 1987 ; Smith *et al.*, 1987 ; Shupeng, 1987 ; Tomlinson, 1987 ; Wiggins *et al.*, 1987) : the selected classes are the same along the different layers, that is not the case in other GISs.

After the standardization of the classes, the maps have been digitized by the mean of a digitizing table coupled to a micro-computer. The classes are described as polygons, vectors and points, and length-limited textual data reference them.

Like the classes, the geometry has been standardized to obtain referenced x-y-coordinates. To replace the different maps into a same grid cells (the Lambert III projection), each map has been geometrically rectified by the mean of a deformation model, computed by a least-square fitting of a second-order polynomial model over a set of couples of landmarks alternatively taken in the digitized map and in the reference map.

However, the sea-shore line of the rectified maps are not the same due to the difference of precision between the initial maps. To complete the geometric rectification in order to keep superimposable the sea-shore line of all maps, a reference sea-shore line has been digitized from the reference map.

2.3 . Structure of the regional GIS

The mapped area is 1960 columns by 760 rows wide, with a pixel equal to 25 m x 25 m. Displaying the entire area with full resolution is not possible with the usual hardware one can find for micro-computer. Hence, the area is divided into eight sectors. Each sector has a size equal or lesser than 440 columns and 360 rows compatible with the most frequent graphical board for micro-computer. Each sector overlaps its neighbours in order to ease the visualisation or the tessellation of two or more sectors.

The structure of each sector is a multi-layers structure. Indeed, each sector is composed of the set of the digitized maps describing it. This set of maps is ordered by their sampling years and are also referenced by the names of authors.

The partition into eight sectors allows a better management of the data and the research of the informations requested is faster. Moreover, this GIS can easily be extended to a larger area just by creating new sectors. These new sectors need not to be contiguous to the initial area.

3 . SYNTHESIS OF THE CONTENTS OF THE GIS

Once the GIS constructed, a method was developed to synthetize the available information. Two maps were computed on a pixel basis for each sector : the synthetic map and the map of "disagreement".

The first one (fig. 2) represents the map of the most fiability. It is composed of the most weighted pixels one can find in the set of data layers. The weight of each pixel of each map depends upon the sampling techniques like airborne surveys, direct submarine observations or bionomic analyses of samples obtained by dredging, combined with the depth of the mapped area. For example, the airborne survey is efficient only for depths lower than 25 m in the area under study (Boudouresque and Meinesz, 1982), and often, maps drawn up by this technique result of interpolation for larger depths. In shallow water, this technique gives a good precision for the boundaries of the different benthic communities but these communities cannot be accurately labelled by an aerial view and external knowledge is required to draw up the map. On the contrary, the dredging technique gives accurate results about the communities themselves, but their boundaries must be extrapolated.

The synthesis also takes into account the age of each map. When a pixel corresponds to different communities in two or more different maps and if these maps presents, at this pixel the same weight, the priority is given to the latest made.

The map of "disagreement" (fig. 3) is computed at the same time that the synthetic map. It exhibits at each pixel the difference between the community selected in the synthetic map and the most frequent community in the set of maps, taking the weight into account (modal class).

4 . CONCLUSION

The first usefulness of this GIS is the gathering in the same place of maps of the area under study. Once the data stored onto an optical digital disk the retrieval of the requested informations is faster because the informations are immediatly and easily accessible, and also is more efficient because the maps are in a same geographical frame and are superimposable and therefore immediatly comparable.

This GIS allows the user to examine spatial evolutions and temporal dynamics of the benthic communities (Meaille *et al.*, 1988).

The map of "disagreement" is of great interest for further mapping since it shows the places where data are lacking or where time evolution occurs.

Usually GISs are composed of layers of data which differ ones the others by their themes. Our GIS takes into account twelve classes and is composed of layers of data which are representations of the same theme. This GIS can be considered as a set of representations of a stochastic process with natural trend because the thematic scenes are the same but seen at different moments with different sampling techniques as well as different oceanographers. The aim of the synthetic map and the map of "disagreement" is to distinguish the natural evolution from this random variable.

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LISTE DES FIGURES

Fig. 1 : Map showing the area under study.

Fig. 2 : Synthetic map of the total area after tessellation of the eight sectors. The grey scale shows the nine groups including the twenty classes of benthic communities.

Fig. 3 : Map of disagreement of the third sector. It depicts the difference between the synthetic and the modal class. This difference is coded with three values, each represents a type of disagreement :

- 0 indicates a perfect agreement,
- 10 indicates a disagreement between classes within one group,
- 20 indicates a disagreement between groups.

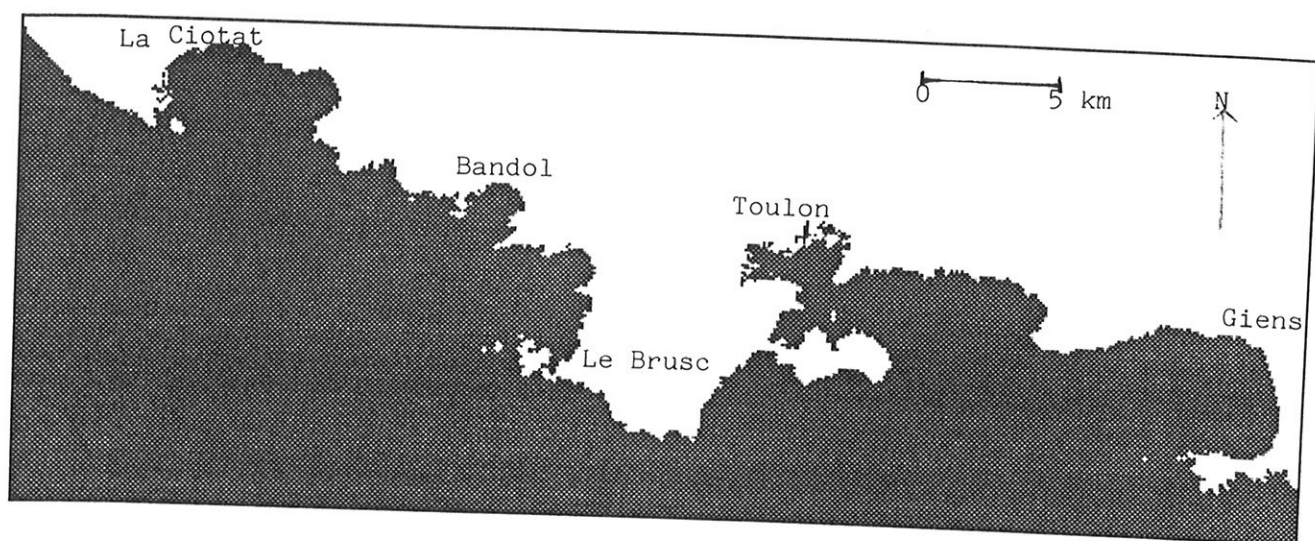


Fig. 1 :

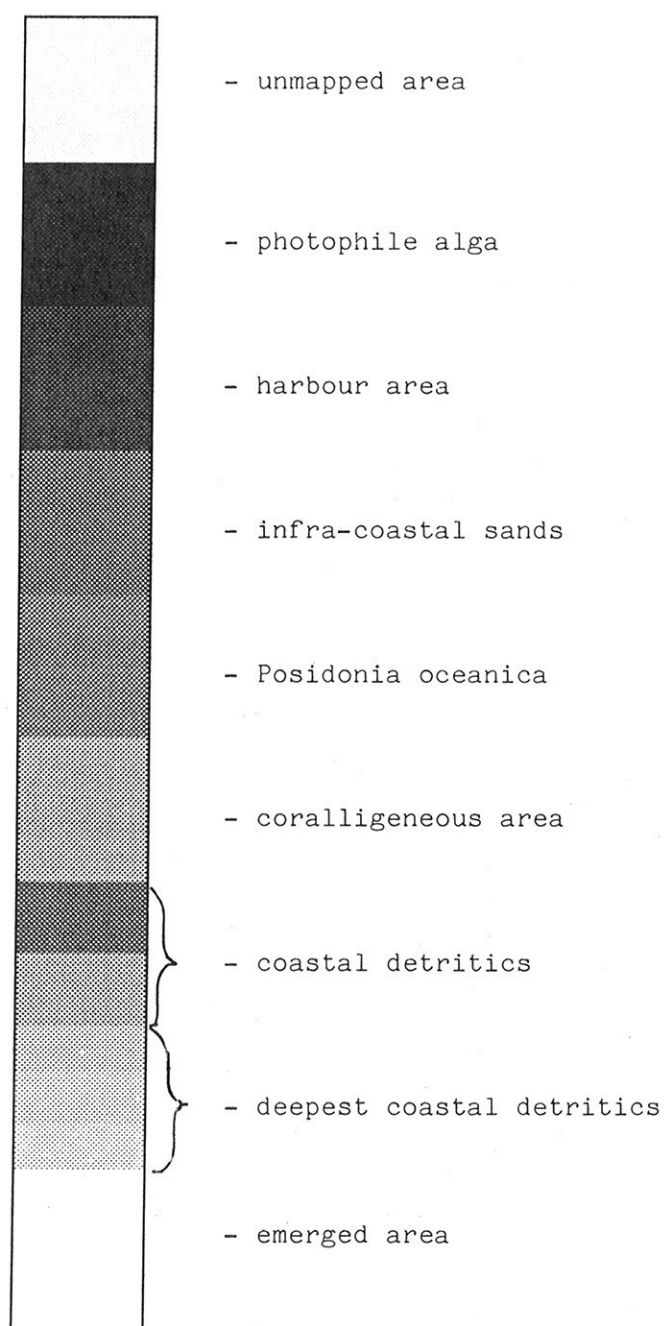
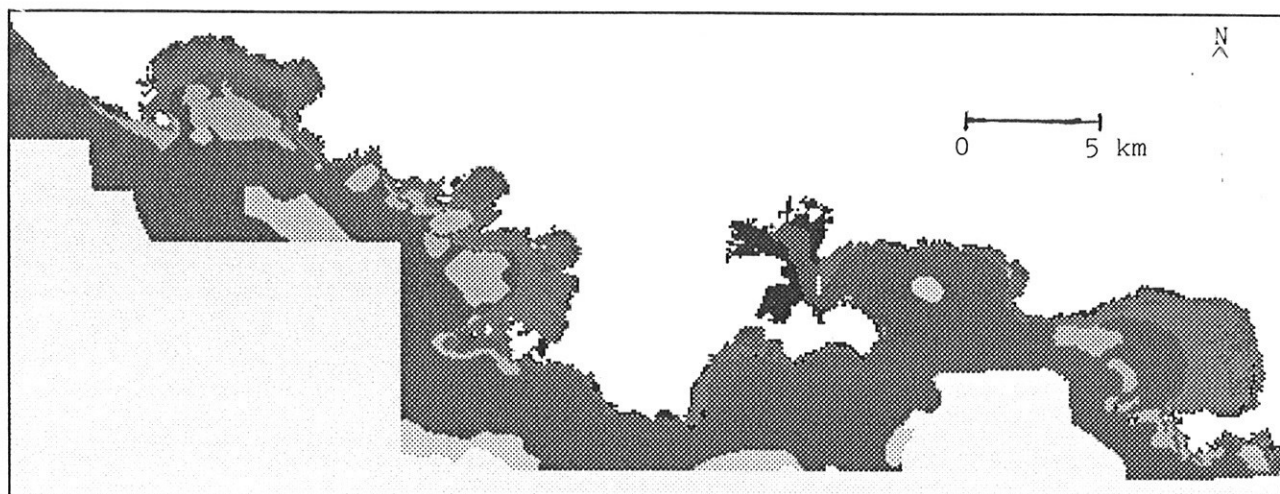


Fig. 2 :

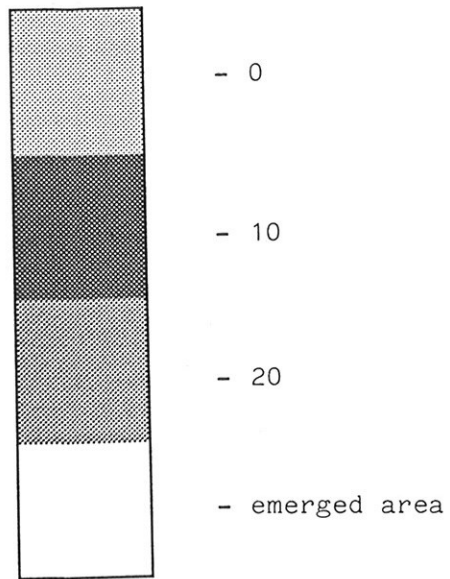
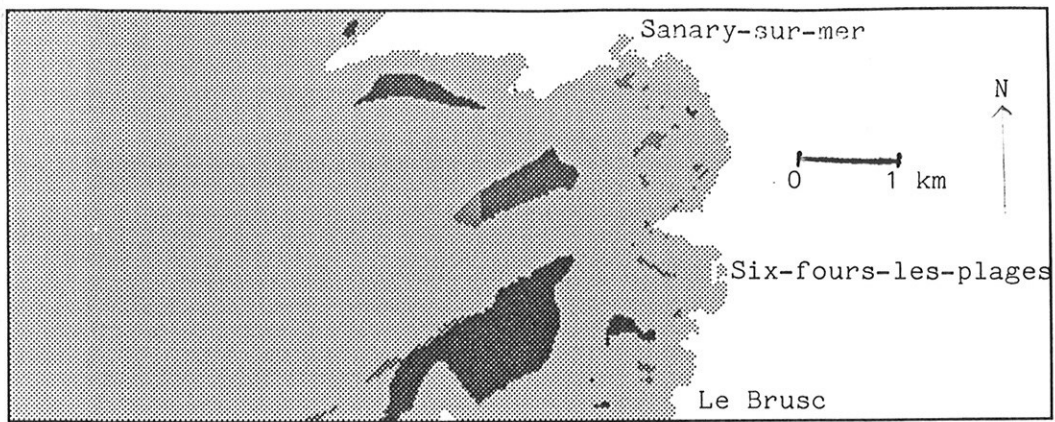


Fig. 3 :